

QQdecdef

redefining particle decays

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- Purpose
- Procedure & proof of algorithm
- QQdecdef.pl: *perl* implementation
- Use, input parameter file
- Output
- Printing decay chains
- Combining decay files using *ghosts*
- QQ: remedying semileptonic routines
 - cloning* particle id codes
- QQ: fixing precision bug

- Purpose:
 - ✓ produce clean MC samples
 - ✓ reduce generation time and sample sizes
- How:
 - ✓ overwrite relevant particle decays
 - ✓ include only decay chains one is interested in for signal reconstruction
- Why is it incorrect to just remove decay lines
 - ✓ relative probability for decay chains becomes inconsistent
 - ✓ need to re-calculate particle branching ratios...

Procedure

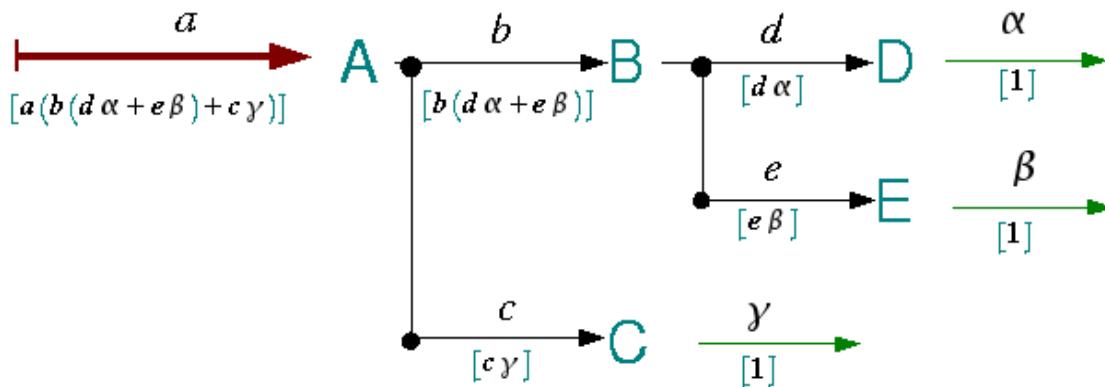
- Re-define parent particle(s) decays
 - ✓ from full decay file select relevant decays
- Re-define daughter particles
 - ✓ assign name, (available) QQ code id
 - ✓ this ensures only the particle instances involved in the full decay chain are redefined
- Update branching fraction values
 - ✓ multiply BR values recursively, backwards along the decay chain
 - ✓ this ensures chain relative probabilities are preserved
- Normalize BR values
 - ✓ for each particle, divide the 'updated' BR values of its selected daughters by the respective sum
 - ✓ also done automatically by decay package

Proof of algorithm

Compare ratio of probabilities of chains $ABD \rightarrow$ and $AC \rightarrow$

Before: $\frac{P(ABD)}{P(AC)} = \frac{ab d \alpha}{ac \gamma}$

After: $\frac{P(ABD)}{P(AC)} = \frac{a'b'd'\alpha'}{a'c'\gamma'} = \frac{b'd'\alpha'}{c'\gamma'} = \frac{\frac{b(d\alpha+e\beta)}{b(d\alpha+e\beta)+c\gamma} * \frac{d\alpha}{d\alpha+e\beta} * \frac{\alpha}{\alpha}}{\frac{c\gamma}{b(d\alpha+e\beta)+c\gamma} * \frac{\gamma}{\gamma}} = \frac{bd\alpha}{c\gamma}$



Perl implementation

Module examples:

Displaying decay chains

Redefining branching ratios

```

sub redefine_dec_br{
    for ($i=0; $i<=$#decpart_order; $i++) {
        $p=$decpart_order[$i][0];
        $p_=$decpart_order[$i][1];
        $dsbr=sum_bratio($p);
        for ($j=0; $j<=$#decpart_order; $j++) {
            $part=$decpart_order[$j][0];
            $part_defr="dec_defr$part";
            foreach $n (@$part_defr) {
                my $n1=$n;
                if ( $n1 =~ "CHANNEL" ) {
                    if ( $n1 =~ $p_ ) {
                        my @chn = split(/ +/, $n1);
                        my $br_old=$chn[2];
                        my $br_new=$br_old*$dsbr;
                        $n =~ s/$br_old/$br_new/;
                    }
                }
            }
        }
    }
}

```

```

sub print_chain {
    my $i=$_[0]; []
    my $j=$_[0];
    my $pt=$_[1];
    print OFC "\n\n *****\tPrinting $pt decay chains...\n\n" if $i==0;
    my $num=$pdaughter{$pt}[0][0]+1;
    print OFC "      $pt\t\t \n" if $i==0;

    for $i0 ( 1 .. $num) {
        my $j=$i; $j++;
        my $num_p0=$pdaughter{$pt}[0][$i0]+1;
        my $dau1 = "@{ $pdaughter{$pt}[$i0] }";
        if ( $pt =~ "B0" ) { $dau1="$pdaughter{$pt}[$i0][3]"; }
        else { $dau1="$pdaughter{$pt}[$i0][1]"; }
        my $numd1=$pdaughter{$dau1}[0][0]+1;
        if ($i0==1) {
            print OFC "\t," " |\t\t x $i, "--o-->\t$dau1\n";
        } elsif ($i0<$num) {
            if ($i==2) { print OFC "\t," " |\t\t x $i, " |--->\t$dau1\n"; }
            else { print OFC "\t," " |\t\t x $i, " |--->\t$dau1\n"; }
        } else {
            if ($i==2) { print OFC "\t," " |\t\t x $i, " |--->\t$dau1\n"; }
            else { print OFC "\t," " |\t\t x $i, " |--->\t$dau1\n"; }
        }
    }

    print_chain ($j,$dau1) if ( $dau1 !~ 'K\+' && $i<20);
}

print OFC "\n\n\n" if $i==0;
print OFC "\t |\t\t \n" if $i==1;
print OFC "\t |\t\t |\n" if $i==2;
}

```

Input parameter file

Usage: ./Qqdecdef.pl input.DEF

```
#Enter talk-to parameters:  
DecayFile set decay.CDF  
ParentP set B0  
DaughterP set D-  
SemiEle set 0  
SemiMuon set 1  
SemiLep set 1  
ModSelect set 1  
PrefName set MY;  
AidJump set 20  
Precision set %0.4f  
VerboseL set 2
```

```
#Enter decays of DaughterP:
```

```
DECAY D-  
CHANNEL K*0 PI-  
CHANNEL K0*0 PI-  
CHANNEL K+ PI- PI-  
ENDDECAY  
  
DECAY K*0  
CHANNEL K+ PI-  
ENDDECAY
```

```
DECAY K0*0  
CHANNEL K+ PI-  
ENDDECAY
```

Ouput verbose

```
b0pcmit09"/code/qq > ./QQdecdef.pl input.DEF  
Executing QQdecdef.pl procedure, parameters from input.DEF...  
No CDF2 software version currently set up!  
*****  
  
Bedefining B0 decay: B0 -> D-  
Using decay file: decay.CDF  
Generated files:  
    B0D_initial.DEF      original decays  
    B0D_select.DEF       selected decays  
    B0D_bratio.DEF      redefined BR  
    B0D_final.DEF       normalized BR  
    B0D_chains.DEF      chain printout  
  
perl by: leonardo@fnal.gov 2003-03-xx  
used by: leonardo on Thu Mar 27 at 15:00:44  
  
*****  
Begin: printing verbose (11)...  
Set of parameters employed:  
    DecayFile   : decay.CDF  
    ParentP    : B0  
    DaughterP  : D-  
    SemiLep    : 1  
    SemiEle    : 0  
    SemiMuon   : 1  
    ModSelect  : 1  
    PrefName   : MY  
    AidJump   : 20  
    precision  : %0.4f  
    VL        : 2  
  
List of decaying particles to be considered (9):  
    K*0 D- K0*0 D*- 3P0N 3P1N 1P1N 3P2N B0  
End : printing verbose (12).  
*****  
Ordered list of 9 decaying particles considered:  
    K*0 K0*0 D- D*- 3P2N 1P1N 3P1N 3P0N B0  
The original fraction of cross section 0.093000  
    became after redefinition 0.003492  
The fractions of B0->D- cross section  
    excluded: 98.245%     kept: 3.755%  
Done.  
b0pcmit09"/code/qq >
```

Printing out decay chains

DaughterP decay chains

***** Printing D- decay chains...

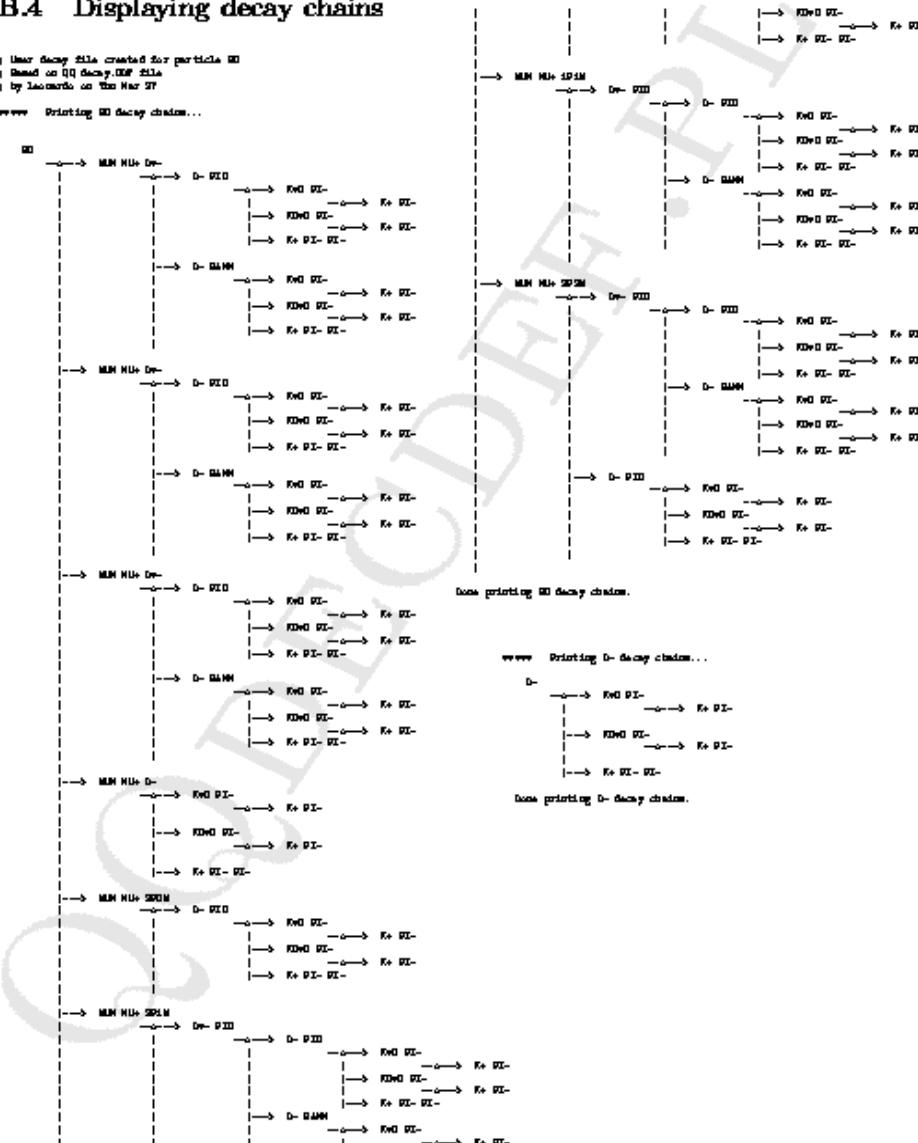
D-
 --o--> K*0 PI-
 |
 |
 |---> K0*0 PI-
 |
 |---> K+ PI- PI-

Done printing D- decay chains.

Full ParentP decay chains

B.4 Displaying decay chains

```
| User decay file created for particle 90  
| Based on QCD decay.DAT file  
| by Isowards on the Mac II  
  
www Printing 90 decay chains...
```



Final decay file:

B0D-_final.DEF

```

; User decay file created for particle B0
; Based on QQ decay.CDF file
; by leonardo on Fri Apr  4 2003
;
; Final, normalized decay file
; point to it via QQ_USER_FILE
;
PARTICLE MMYK*0    65   -1  0.896100  0.0  1.0  0.000000  0.0505  0.640  1.150
PDG   MMYK*0      313
PARTICLE MMYD-     30   -1  1.869300 -1.0  0.0  0.000317
PDG   MMYD-      -411
PARTICLE MMYK0*0 268 -1 1.429   0.0 0.0 0.0  0.287  0.830  2.030
PDG   MMYK0*0     10311
PARTICLE MMYD*- 70   -1  2.010000 -1.0  1.0  0.000000
PDG   MMYD*-     -413
PARTICLE MMY3PON 225 -1 2.400  -1.0 0.0 0.0  0.150  2.100  3.000
PDG   MMY3PON     -10411
PARTICLE MMY3P1N 226 -1 2.445  -1.0 1.0 0.0  0.250  2.150  3.400
PDG   MMY3P1N     -20413
PARTICLE MMY1P1N 227 -1 2.423  -1.0 1.0 0.0  0.020  2.343  2.483
PDG   MMY1P1N     -10413
PARTICLE MMY3P2N 228 -1 2.459  -1.0 2.0 0.0  0.023  2.390  2.528
PDG   MMY3P2N     -415
;
DECAY MMYK*0
ANGULAR_HELCITY -1  1.  0.  -1.
ANGULAR_HELCITY  0  0.  0.  1.
ANGULAR_HELCITY  1  1.  0.  -1.
CHANNEL 0 1.0000 K+  PI-
ENDDECAY
;

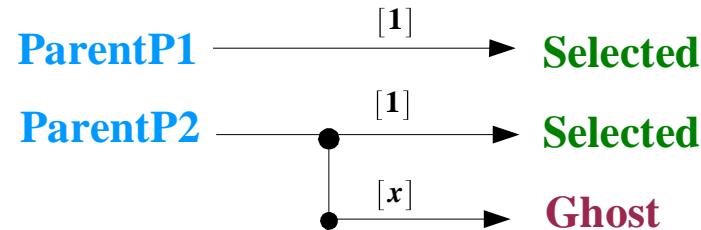
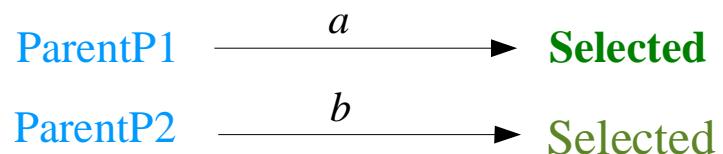
DECAY MMYD-
HELCITY 1.0  0  0
CHANNEL 0 0.1036 MMYK*0  PI-
CHANNEL 0 0.2017 MMYK0*0  PI-
CHANNEL 0 0.6947 K+  PI-  PI-
ENDDECAY
;
DECAY MMYK0*0
CHANNEL 0 1.0000 K+  PI-
ENDDECAY
;

DECAY MMYD*- 
ANGULAR_HELCITY -1  1.  0.  -1.
ANGULAR_HELCITY  0  0.  0.  1.
ANGULAR_HELCITY  1  1.  0.  -1.
CHANNEL 0 0.9482 MMYD-  PIO
ANGULAR_HELCITY -1  1.  0.  1.
ANGULAR_HELCITY  0  1.  0.  -1.
ANGULAR_HELCITY  1  1.  0.  1.
CHANNEL 0 0.0518 MMYD-  GAMM
ENDDECAY
;
DECAY MMY3PON
CHANNEL 0 1.0000 MMYD-  PIO
ENDDECAY
;
DECAY MMY3P1N
CHANNEL 0 1.0000 MMYD*-  PIO
ENDDECAY
;
DECAY MMY1P1N
HELCITY 0.20  1  -1
HELCITY 0.80  0  0
CHANNEL 0 1.0000 MMYD*-  PIO
ENDDECAY
;
DECAY MMY3P2N
HELCITY 1.0  1  1
CHANNEL 0 0.1283 MMYD*-  PIO
CHANNEL 0 0.8717 MMYD-  PIO
ENDDECAY
;
DECAY B0
HELCITY 1.0  0  0  1
CHANNEL 52 0.0960 NUM  MU+  MMYD*- 
HELCITY 1.0  0  0  -1
CHANNEL 52 0.0960 NUM  MU+  MMYD*- 
HELCITY 1.0  0  0  0
CHANNEL 53 0.2171 NUM  MU+  MMYD*- 
CHANNEL 51 0.4637 NUM  MU+  MMYD- 
CHANNEL 51 0.0170 NUM  MU+  MMY3PON
CHANNEL 51 0.0055 NUM  MU+  MMY3P1N
CHANNEL 51 0.0303 NUM  MU+  MMY1P1N
CHANNEL 51 0.0744 NUM  MU+  MMY3P2N
ENDDECAY
;
```

Combining decay files

- Use concatenated decay file, and write separately to independent streams for each original parent decay particle; combine contributions appropriately at the reconstruction level
- Produce a single sample type with natural mixtures of contributing particles, using the method of

renomalizing ghost



Determination of x :

$$\frac{a}{b} = \frac{1}{\frac{1}{1+x}}$$

$$x = \frac{a}{b} - 1$$

Name: inspired from QFT

Example of combined decay file: D- sample

```

;Combined decay files for: B+,B0 -> D- X -> K 2Pi X
;
;define ghost particles as stable gravitons
PARTICLE GHOST1 595 0 0.769900 1.0 1.0 0.000000 0.1512 0.300 1.200
PARTICLE GHOST2 596 0 0.957770 0.0 0.0 0.000000 0.0002 0.955 0.960
PDG GHOST1 39
PDG GHOST2 39
;
;define all other particles
PARTICLE JK*0 590 -1 0.896100 0.0 1.0 0.000000 0.0505 0.640 1.150
PDG JK*0 313
PARTICLE JK0*0 591 -1 1.429 0.0 0.0 0.0 0.287 0.830 2.030
PDG JK0*0 10311
PARTICLE JD- 350 -1 1.869300 -1.0 0.0 0.000317
PDG JD- -411
PARTICLE JD*- 370 -1 2.010000 -1.0 1.0 0.000000
PDG JD*- -413
PARTICLE J3PON 325 -1 2.400 -1.0 0.0 0.0 0.150 2.100 3.000
PDG J3PON -10411
PARTICLE J3P1N 326 -1 2.445 -1.0 1.0 0.0 0.250 2.150 3.400
PDG J3P1N -20413
PARTICLE J1P1N 327 -1 2.423 -1.0 1.0 0.0 0.020 2.343 2.483
PDG J1P1N -10413
PARTICLE J3P2N 328 -1 2.459 -1.0 2.0 0.0 0.023 2.390 2.528
PDG J3P2N -415
PARTICLE J3POB 333 -1 2.400 0.0 0.0 0.0 0.150 2.100 3.000
PDG J3POB -10421
PARTICLE J3P1B 334 -1 2.445 0.0 1.0 0.0 0.250 2.150 3.400
PDG J3P1B -20423
PARTICLE J1P1B 335 -1 2.423 0.0 1.0 0.0 0.020 2.343 2.483
PDG J1P1B -10423
PARTICLE J3P2B 336 -1 2.459 0.0 2.0 0.0 0.023 2.390 2.528
PDG J3P2B -425
;
;Re-define decays of B particles
DECAY B+
CHANNEL 51 0.0739 NUM MU+ J3POB
CHANNEL 51 0.0240 NUM MU+ J3P1B
CHANNEL 51 0.2635 NUM MU+ J1P1B
CHANNEL 51 0.6387 NUM MU+ J3P2B
;add ghost channel with appropriate BR value
CHANNEL 0 3.2794 GHOST1 GHOST2
ENDDECAY

DECAY BO
HELICITY 1.0 0 0 1
CHANNEL 52 0.0960 NUM MU+ JD--
HELICITY 1.0 0 0 -1
CHANNEL 52 0.0960 NUM MU+ JD--
HELICITY 1.0 0 0 0
CHANNEL 53 0.2171 NUM MU+ JD--
CHANNEL 51 0.4637 NUM MU+ JD-
CHANNEL 51 0.0170 NUM MU+ J3PON
CHANNEL 51 0.0055 NUM MU+ J3P1N
CHANNEL 51 0.0303 NUM MU+ J1P1N
CHANNEL 51 0.0744 NUM MU+ J3P2N
ENDDECAY
;
;all remaining decays stay unchanged
;relatively to the individual decay files
;k decays
DECAY JK*0
ANGULAR_HELICITY -1 1. 0. -1.
ANGULAR_HELICITY 0 0. 0. 1.
ANGULAR_HELICITY 1 1. 0. -1.
CHANNEL 0 1.0000 K+ PI-
ENDDECAY
;
DECAY JK0*0
CHANNEL 0 1.0000 K+ PI-
ENDDECAY
;
;D decays
DECAY JD-
HELICITY 1.0 0 0
CHANNEL 0 0.1036 JK*0 PI-
CHANNEL 0 0.2017 JK0*0 PI-
CHANNEL 0 0.6947 K+ PI- PI-
ENDDECAY
;
;D* decays
DECAY JD*-
ANGULAR_HELICITY -1 1. 0. -1.
ANGULAR_HELICITY 0 0. 0. 1.
ANGULAR_HELICITY 1 1. 0. -1.
CHANNEL 0 0.9482 JD- PIO
ANGULAR_HELICITY -1 1. 0. 1.
ANGULAR_HELICITY 0 1. 0. -1.

ANGULAR_HELICITY 1 1. 0. 1.
CHANNEL 0 0.0518 JD- GAMM
ENDDECAY
;
;D** decays
DECAY J3PON
CHANNEL 0 1.0000 JD- PIO
ENDDECAY
;
DECAY J3P1N
CHANNEL 0 1.0000 JD-- PIO
ENDDECAY
;
DECAY J1P1N
HELICITY 0.20 1 -1
HELICITY 0.80 0 0
CHANNEL 0 1.0000 JD-- PIO
ENDDECAY
;
DECAY J3P2N
HELICITY 1.0 1 1
CHANNEL 0 0.1283 JD-- PIO
CHANNEL 0 0.8717 JD- PIO
ENDDECAY
;
DECAY J3POB
CHANNEL 0 1.0000 JD- PI+
ENDDECAY
;
DECAY J3P1B
CHANNEL 0 1.0000 JD-- PI+
ENDDECAY
;
DECAY J1P1B
HELICITY 0.20 1 -1
HELICITY 0.80 0 0
CHANNEL 0 1.0000 JD-- PI+
ENDDECAY
;
DECAY J3P2B
HELICITY 1.0 1 1
CHANNEL 0 0.1281 JD-- PI+
CHANNEL 0 0.8719 JD- PI+
ENDDECAY

```

Problems with QQ semileptonic decays implementation

The implementation of semileptonic decay routines in QQ is made in an unsatisfactory way:

Various internal variables have explicit dependence on particle QQ id (specifying this way eg which form factor model/parameterization is to be used)

A direct, undesirable consequence is the following:
one cannot redefine particle decays properly;
i.e., new QQ id codes assigned to decay particles are not recognized by the code.

This has been fixed by modifying the
SEMIL1, SEMIL2, SEMIL3
Fortran subroutines in a private version of the QQ products.

C L O N I N G Q Q

I D

S *MIT analysis meeting*

| Particle | PDG | QQ name | original id | clone id |
|------------------|--------|---------|-------------|----------|
| D^0 | 421 | D0 | 27 | 247 |
| \bar{D}^0 | -421 | D0B | 28 | 348 |
| D^+ | 411 | D+ | 29 | 349 |
| D^- | -411 | D- | 30 | 350 |
| D_S^+ | 431 | DS+ | 31 | 351 |
| D_S^- | -431 | DS- | 32 | 352 |
| D^{*0} | 423 | D^*0 | 67 | 367 |
| \bar{D}^{*0} | -423 | D^*B | 68 | 368 |
| D^{*+} | 431 | D^*+ | 69 | 369 |
| D^{*-} | -431 | D^*- | 70 | 370 |
| D_0^{*+} | 10411 | 3P0P | 221 | 321 |
| $D_1(H)^+$ | 20413 | 3P1P | 222 | 322 |
| $D_1(2420)^+$ | 10413 | 1P1P | 223 | 323 |
| $D_2^*(2460)^+$ | 415 | 3P2P | 224 | 324 |
| D_0^{*-} | -10411 | 3P0N | 225 | 325 |
| $D_1(H)^-$ | -20413 | 3P1N | 226 | 326 |
| $D_1(2420)^-$ | -10413 | 1P1N | 227 | 327 |
| $D_2^*(2460)^-$ | -415 | 3P2N | 228 | 328 |
| D_0^{*0} | 10421 | 3P00 | 229 | 329 |
| $D_1(H)^0$ | 20423 | 3P10 | 230 | 330 |
| $D_1(2420)^0$ | 10423 | 1P10 | 231 | 331 |
| $D_2^*(2460)^0$ | 425 | 3P20 | 232 | 332 |
| \bar{D}_0^{*0} | -10421 | 3P0B | 233 | 333 |
| $D_1(\bar{H})^0$ | -20423 | 3P1B | 234 | 334 |
| $D_1(2420)^0$ | -10423 | 1P1B | 235 | 335 |
| $D_2^*(2460)^0$ | -425 | 3P2B | 236 | 336 |

QQ bug causing systematic crashes

- Identified by Ilya
- In **qq_libu.F**
- Caused job crashes: ~ 10^5 events/crash
- Related to precision handling
- Modified macro in source file
$$\text{PAWT}(A,B,C) = \text{SQRT}((A^{**2}-(B+C)^{**2})*(A^{**2}-(B-C)^{**2}))/(2.*A)$$
into
$$\text{PAWT}(A,B,C)=\text{SQRT}(\text{ABS}((A^{**2}-(B+C)^{**2})*(A^{**2}-(B-C)^{**2}))) / (2.*A)$$
- Code has been recompiled, and GenTrig executable rebuilt

Documentation

QQ decay files

Purpose

Describe QQdecdef.pl -- a tool providing corrected branching fractions in user decay files.

General

QQ provides at CDF a MC package suitable for decaying heavy flavor. Particle decays are specified in decay files:

- standard decay file: `QQ_DECAY_FILE decay.CDF`
- user decay file: `QQ_USER_FILE`

User decay files are used for specifying selected particle decays; and may in general be produced by selecting and modifying patches of the standard decay file; in cases where the cut-paste-and-delete method does not apply, one may consider making use of the tool described next.

Tool: `QQdecdef.pl`

This is a tool implementing a procedure whose purpose is to produce correct user decay files (e.g., with correct values of particle branching fractions). The main script file (`QQdecdef.pl`) takes as input an appropriate QQ standard decay file (`decay.CDF`) and a parameter file (`input.DEF`). When executed:

```
QQdecdef.pl <input.DEF>
```

produces output files including the final user decay file and decay chains printout, according to the parameters specified.

Example: $B^0 \rightarrow \mu^+ D^- X \rightarrow K^+ \bar{\nu}_\mu \pi^- \bar{\nu}_\pi X$

Semi-muonic decays of B_0 , leading to $K2\pi$ final state originating from D^-

- `input.DEF`: parameter file
- `B0D_initial.DEF`: initial decays
- `B0D_select.DEF`: selecting decays
- `B0D_bratio.DEF`: redefining particles, updating BR's
- `B0D_final.DEF`: final decay file
- `B0D_chains.DEF`: printing decay chains

Documentation

- note (.ps, .pdf)
- slides (.ps)

CDF/DOC/MONTECARLO/PUBLIC/xxxx
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Redefining decay files

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Abstract

This note introduces a procedure for correctly producing QQ user decay files, and describes a tool which implements it.

The procedure's implementation takes as input a standard QQ decay file, and produces user decay files defining the specified decays, with corrected, normalized values for the branching fractions. It provides a graphical representation of the decay chains involved.

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